



DECLARATION

I, Kyoko Okumura, the translator of the attached document, do hereby certify that to the best of my knowledge and belief, the attached document is true English translation of Japanese Patent Application No. 2003-079206.

Signed, this twenty-sixth day of September, 2006

A handwritten signature in black ink, appearing to be "Kyoko Okumura", written over a horizontal line.

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Electrophotographic Conductor, Production Method of
Electrophotographic Conductor, and Image Forming Apparatus

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[Title of the Invention]

Electrophotographic Conductor, Production Method of
Electrophotographic Conductor, and Image Forming Apparatus

[Scope of Claims.]

[Claim 1]

An electrophotographic photoconductor comprising a charge transport layer having at least a charge generation layer, and a halogen-free solvent in the order on an electroconductive support body, characterized by including a charge generation material having an average particle diameter smaller than surface roughness of the electroconductive support body in the charge generation layer, and a polyvinyl acetal resin having a ratio (Mw/Mn) of weight-average molecular weight (Mw) to an amount of number-average molecular weight (Mn) of 2.2 or more.

[Claim 2]

The electrophotographic photoconductor comprising the charge transport layer having at least a middle layer, the charge generation layer, and the halogen free solvent in the order on the electroconductive support body, characterized by including a charge generation material having an average particle diameter smaller than surface roughness of the middle layer in the charge generation layer, and a polyvinyl acetal resin having a ratio (Mw/Mn) of weight-average molecular weight Mw to an amount of number-average molecular weight of 2.2 or more.

[Claim 3]

The electrophotographic photoconductor according to claim 1 or 2, characterized in that an average particle diameter of the charge generation material is 0.3 μm or less, and two-thirds or less of the surface roughness of a surface on which the charge generation layer is formed, and the charge generation material comprises a polyvinyl acetal resin having an amount of number-average molecular weight M_n of 100,000 or more in polystyrene conversion.

[Claim 4]

The electrophotographic photoconductor according to any one of claims 1 through 3, characterized in that the charge generation material is titanyl phthalocyanine.

[Claim 5]

The electrophotographic photoconductor according to claim 4, characterized in that the titanyl phthalocyanine reaches a maximum peak at a Bragg angle 2θ of $27.2^\circ \pm 0.2^\circ$, for Cu- $k\alpha$ radiation (wave length of 1.542Å).

[Claim 6]

The electrophotographic photoconductor according to claim 5, characterized in that the titanyl phthalocyanine reaches a maximum peak at a Bragg angle 2θ of $27.2^\circ \pm 0.2^\circ$, reaches a peak at a lowest Bragg angle of $23^\circ \pm 0.2^\circ$, and has no maximum peak at a range of 7.4° to 9.4° , for Cu- $k\alpha$ radiation (wave length of 1.542Å).

[Claim 7]

The electrophotographic photoconductor according to claim 6, characterized in that the titanyl phthalocyanine reaches no maximum peak also at 26.3° .

[Claim 8]

The electrophotographic conductor according to any one of claims 1 through 7, characterized in that the titanyl phthalocyanine is dispersed such that an average particle diameter becomes 0.3 μm or less, and a standard deviation of the titanyl phthalocyanine becomes 0.2 μm or less, and then by using a dispersed liquid filtered through a filter with an effective pore size of 3 μm or less, the charge generation layer is coated.

[Claim 9]

The electrophotographic conductor according to any one of claims 1 through 7, characterized in that, as a diffraction peak ($\pm 0.2^\circ$) of a Bragg angle 2θ for Cu-K α characteristic X-ray (wave length of 1.542Å), the titanyl phthalocyanine reaches the maximum peak at least within 7.0° and 7.5° , amorphous titanyl phthalocyanine or low crystalline titanyl phthalocyanine of which a half width of the diffraction peak is 1° or more having an average size of a primary particle of $0.1\text{ }\mu\text{m}$ or less is crystallized in water by using an organic solvent, and by the organic solvent, the crystallized titanyl phthalocyanine is separated and filtered before the average size of the primary particle grows to more than $0.3\text{ }\mu\text{m}$ after crystallization.

[Claim 10]

The electrophotographic conductor according to any one of claims 1 through 9, characterized in that the charge transport layer comprises polycarbonate including at least a triarylamine structure in a principal chain and/or a side chain.

[Claim 11]

The electrophotographic conductor according to any one of claims 1 through 8, characterized in that a surface protection layer is formed on the charge transport layer.

[Claim 12]

The electrophotographic conductor according to claim 11, characterized in that an inorganic pigment or metal oxide having a specific resistance of $10^{10}\text{ }\Omega\text{ cm}$ or more is included in the protection layer.

[Claim 13]

The electrophotographic conductor according to claim 12, characterized in that the metal oxide is any one of alumina, titanium oxide, and silica having a specific resistance of $10^{10}\text{ }\Omega\text{ cm}$ or more.

[Claim 14]

The electrophotographic conductor according to claim 13,

characterized in that the metal oxide is α -alumina having a specific resistance of $10^{10} \Omega \text{ cm}$ or more.

[Claim 15]

5 The electrophotographic conductor according to any one of claims 11 through 14, characterized in that the protection layer comprises a polymer charge transport material.

[Claim 16]

10 The electrophotographic conductor according to any one of claims 1 through 15, characterized in that a surface of the electroconductive support body thereof has been subjected to an anodic oxide film processing.

[Claim 17]

15 A production method of the photographic conductor according to any one of claims 1 through 16, characterized by using a halogen-free solvent selected from at least cyclic ether, or aromatic hydrocarbon as a coating solvent for the charge transport layer.

[Claim 18]

20 An image forming apparatus comprising an image forming element including at least a charge means, an exposure means, a development means, a transfer means, and the electrophotographic conductor, characterized in that the electrophotographic conductor is the electrophotographic conductor according to any one of claims 1 through 16.

[Claim 19]

25 The image forming apparatus according to claim 18, characterized by aligning a plurality of the image forming elements.

[Claim 20]

30 The image forming apparatus according to claim 18 or 19, characterized by using a light emitting diode, or semiconductor laser as an exposure means.

[Claim 21]

The image forming apparatus according to any one of claims 18 through 20, characterized by using a contact charge method as the

charge method.

[Claim 22]

The image forming apparatus according to any one of claims 18 through 20, characterized by using a non-contact close spacing
5 method as the charge method.

[Claim 23]

The image forming apparatus according to claim 22, characterized in that a gap between a charge member used for the charge means, and a photoconductor is 200 μm or less.

10 [Claim 24]

The image forming apparatus according to any one of claims 21 through 23, characterized by applying an alternating superimposed voltage as the charge means.

[Claim 25]

15 A process cartridge for the image forming apparatus characterized by comprising at least the electrophotographic conductor according to any one of claims 1 through 16.

20

[Detailed Description of the Invention]

[0001]

[Technical Field]

25 The present invention relates to an electrophotographic conductor having at least a charge generation layer and a charge transport layer, an electrophotographic apparatus using the electrophotographic conductor, and a process cartridge in the order for the image forming apparatus. More specifically, the present
30 invention relates to an electrophotographic conductor exhibiting a little sensitivity variation when a halogen-free coating solvent is used and excelling in chargeability, and an image forming apparatus using the electrophotographic conductor, and a process

cartridge for the image forming apparatus.

[0002]

[Background Art]

Recent development of information processing system devices
5 using an electrophotographic method is remarkable. Especially,
print quality, and reliability of an optical printer which performs
optical information recording by converting information to a
digital signal are significantly improved. A digital recording
technology is applied not only to printers, but also to regular
10 copiers, and consequently so-called digital copiers are developed.
Since various types of many information processing functions are
added to a copier equipped with the digital recording technique
in addition to a conventional analogue copying technique, a market
demand is predicted to grow further. In addition, together with
15 diffusion of computers, and improved functions of the computers,
digital color printers for outputting an image and a document in
color is rapidly advanced.

[0003]

Today, as a photoconductive material, the electrophotographic
20 conductor using an organic photoconductive material superior in
sensitivity, thermal stability, toxicity, and so forth to a
conventionally used inorganic material, such as Se, CdS, ZnO, and
so forth is mainly used in the image forming apparatuses. When a
photoconductive layer of the electrophotographic conductor using
25 the organic photoconductive material is formed, an organic
photoconductive material of a functionally separated type in which
a charge transport layer is layered on a charge generation layer
is typically used due to excellent stability and resistance.

[0004]

30 As the charge generation material included in the charge
generation layer, a number of charge generation materials, such
as various azo pigments, polycyclic quinone pigments, trigonal
selenium, and various phthalocyanine pigments are developed. Among

such materials, the phthalocyanine pigments exhibit high sensitivity to light with a long wavelength of 600 nm to 800 nm, and are extremely important and useful as a photoconductive material for an electrophotographic printer or a digital copier having an optical source of LED or LD.

[0005]

The charge transport layer is mainly formed of the charge transport material and a binder resin, and typically formed by applying a coating solvent of the materials dissolved, or dispersed in a solvent. A halogen solvent, such as dichloromethane, chloroform, and so forth are mainly used as the solvent since characteristics in solubility and a coating ability excel.

[0006]

In recent years, due to heightened awareness of environmental issues, development of a photoconductor using a halogen-free solvent having little impact on a human body and environment is desired. However, when a coating solvent for the charge transport layer using the halogen-free solvent is employed in production of a photoconductor, although improvement in chargeability is observed, optical sensitivity of the photoconductor declines in initial use, or with repeated use.

For prevention of a sensitivity decline, a method by which optical sensitivity is increased by minimizing a particle diameter of phthalocyanine through milling processing is disclosed (e.g., Patent document 1, Non-Patent document 1).

[0007]

A type of titanyl phthalocyanine containing a specific ratio of chlorinated titanyl phthalocyanine with respect to an unsubstituted titanyl phthalocyanine, and a type of titanyl phthalocyanine having a particle diameter of 1 μm or less are disclosed (e.g., Patent document 2).

When the halogen-free solvent is used as the coating solvent for the charge transport layer by the methods, although improvement

in optical sensitivity is observed, a decline in optical sensitivity is large. Although marked sensitivity is exhibited as an initial characteristic, sensitivity dramatically declines with repeated use.

5 [0008]

Further, as a method using the halogen-free solvent, for example, a method in which a dioxolane compound is used as a halogen-free organic solvent is disclosed. Furthermore, a cyclic ether solvent, such as tetrahydrofuran, etc. generates peroxide if left behind.
10 Hence, a method for adding a stabilizing agent such as, a specific antioxidant, an ultraviolet absorber, etc. to a coating solvent for the charge transport layer using the solvent is disclosed (e.g., Patent documents 3, and 4).

Despite the methods, problems such as an insufficient effect
15 exerted on the above noted shortcomings, or a further deterioration of a sensitivity characteristic affected by an additive are yet unsolved.

Therefore, even in a case where a halogen-free solvent is used as the coating solvent for the charge transport layer, complete
20 development of an electrophotographic photoconductor exhibiting no decline in sensitivity in initial use and with repeated use having excellent chargeability, an image forming apparatus using the electrophotographic photoconductor, and a process cartridge for the apparatus is desired.

25 [0009]

[Patent document 1]

Japanese Patent Application Laid-Open No.Hei4-318557 (page 3, left column, lines 5-33)

[Patent document 2]

30 Japanese Patent Application Laid-Open No.2001-115054 (claim 1, claim 3, page 3, right column, lines 10-20)

[Patent document 3]

Japanese Patent Application Laid-Open No.Hei10-326023 (claim 1,

claim 3, page 3, left column, lines 15-21)

[Patent document 4]

Japanese Patent Application Laid-Open No.2001-356506 (claim 1,
claim 5, page 5, right column, lines 41-45)

5 [Non-patent document 1]

Journal of Imaging Science. 1991, 35(4):235

[0010]

[Problems to be Solved]

10 The present invention aims to provide an electrophotographic
conductor having no sensitivity decline in initial use, and with
repeated use when a halogen-free solvent is used as a coating solvent
for a charge transport layer and excelling in chargeability, the
production method, an image forming apparatus using the
electrophotographic conductor, and a process cartridge for
15 electrophotography.

[0011]

[Means for Solving the Problems]

20 As a result of thorough investigations to solve a problem of
sensitivity decline generated when the halogen-free solvent is used,
inventors of the present invention and co-workers have completed
the present invention.

25 More specifically, above described objectives are achieved by
using (1) "An electrophotographic photoconductor including a charge
transport layer having at least a charge generation layer, and a
halogen-free solvent in the order on an electroconductive support
body characterized by forming a charge generation material having
an average particle diameter smaller than surface roughness of the
electroconductive support body in the charge generation layer, and
a polyvinyl acetal resin having a ratio (Mw/Mn) of weight-average
30 molecular weight Mw to an amount of number-average molecular weight
of 2.2 or more", (2) "The electrophotographic photoconductor
including the charge transport layer having at least a middle layer,
the charge generation layer, and the halogen free solvent in the

order on the electroconductive support body characterized by forming a charge generation material having an average particle diameter smaller than surface roughness of the middle layer in the charge generation layer, and a polyvinyl acetal resin having a ratio
5 (Mw/Mn) of weight-average molecular weight Mw to an amount of number-average molecular weight of 2.2 or more", (3) "The electrophotographic photoconductor according to (1) or (2) as described above characterized in that an average particle diameter of the charge generation material is 0.3 μm or less, and two-thirds
10 or less of the surface roughness of a surface on which the charge generation layer is formed, and the charge generation material includes a polyvinyl acetal resin having number-average molecular weight Mn of 100,000 or more in polystyrene conversion", (4) "The electrophotographic photoconductor according to any one of (1)
15 through (3) as described above characterized in that the charge generation material is titanyl phthalocyanine", (5) "The electrophotographic photoconductor according to (4) as described above characterized in that the titanyl phthalocyanine reaches a maximum peak at a Bragg angle 2θ of $27.2^\circ \pm 0.2^\circ$, for Cu- α
20 radiation (wave length of 1.542\AA)", (6) "The electrophotographic photoconductor according to (5) as described above characterized in that the titanyl phthalocyanine reaches a maximum peak at a Bragg angle 2θ of $27.2^\circ \pm 0.2^\circ$, and has no maximum peak at a range of 7.4° to 9.4° for Cu- α radiation (wave length of 1.542\AA)", (7)
25 "The electrophotographic photoconductor according to (6) as described above characterized in that the titanyl phthalocyanine reaches no maximum peak also at 26.3° ", (8) "The electrophotographic conductor according to any one of (1) through (7) as described above characterized in that the titanyl
30 phthalocyanine is dispersed such that an average particle diameter becomes 0.3 μm or less, and a standard deviation of the titanyl phthalocyanine becomes 0.2 μm or less, and then by using a dispersed liquid filtered through a filter with an effective pore size of

3 μm or less, the charge generation layer is coated", (9) "The electrophotographic conductor according to any one of (1) through (7) as described above characterized in that, as a diffraction ($\pm 0.2^\circ$) peak of a Bragg angle 2θ for Cu-K α characteristic X-ray (wave length of 1.542 \AA), the titanyl phthalocyanine reaches the maximum peak at least within 7.0° and 7.5° , amorphous titanyl phthalocyanine or low crystalline titanyl phthalocyanine of which a half width of the diffraction peak is 1° or less having an average size of a primary particle of $0.1 \mu\text{m}$ or less is crystallized in water by using an organic solvent, and by the organic solvent, the crystallized titanyl phthalocyanine is separated and filtered before the average size of the primary particle grows to more than $0.3 \mu\text{m}$ after crystallization", (10) "The electrophotographic conductor according to any one of (1) through (9) as described above characterized in that the charge transport layer includes at least polycarbonate forming a triarylamine structure in a principal chain and/or a side chain", (11) "The electrophotographic conductor according to any one of (1) through (8) as described above characterized in that a surface protection layer is formed on the charge transport layer", (12) "The electrophotographic conductor according to (11) as described above characterized in that an inorganic pigment or metal oxide having a specific resistance of $10^{10} \Omega \text{ cm}$ or more is included in the protection layer", (13) "The electrophotographic conductor according to (12) as described above characterized in that the metal oxide is any one of alumina, titanium oxide, and silica having a specific resistance of $10^{10} \Omega \text{ cm}$ or more", (14) "The electrophotographic conductor according to (13) as described above characterized in that the metal oxide is α -alumina having a specific resistance of $10^{10} \Omega \text{ cm}$ or more", (15) "The electrophotographic conductor according to any one of (11) through (14) as described above characterized in that the protection layer includes a polymer charge transport material", and (16) "The electrophotographic conductor according to any one of (1) through

(15) as described above characterized in that a surface of the electroconductive support body thereof has been subjected to an anodic oxide film processing" of the present invention, and nickel.

[0012]

5 In addition, the above described objectives are achieved by using (17) "A production method of the photographic conductor according to any one of (1) through (16) as described above characterized by using a halogen-free solvent selected from at least cyclic ether, or aromatic hydrocarbon as a coating solvent for the charge
10 transport layer" of the present invention.

[0013]

Further, the above described objectives are achieved by using (18) "An image forming apparatus including an image forming element including at least a charge means, an exposure means, a development
15 means, a transfer means, and the electrophotographic conductor, characterized in that the electrophotographic conductor is the electrophotographic conductor according to any one of (1) through (16) as described above", (19) "The image forming apparatus according to (18) as described above characterized by aligning a
20 plurality of the image forming elements", (20) "The image forming apparatus according to (18) or (19) as described above characterized by using a light emitting diode, or semiconductor laser as an exposure means", (21) "The image forming apparatus according to any one of (18) through (20) as described above characterized by
25 using a contact charge method as the charge method", (22) "The image forming apparatus according to any one of (18) through (20) as described above characterized by using a non-contact close spacing method as the charge method", (23) "The image forming apparatus according to (22) as described above characterized in that a gap
30 between a charge member used for the charge means, and a photoconductor is 200 μm or less", and (24) "The image forming apparatus according to any one of (21) through (23) as described above characterized by applying an alternating superimposed voltage

as the charge means" of the present invention.

[0014]

Furthermore, the above described objectives are achieved by using (25) "A process cartridge for the image forming apparatus
5 characterized by including at least the electrophotographic conductor according to any one of (1) through (16) as described above" of the present invention.

[0015]

The present invention is described in detail as follows. The
10 halogen-free solvent used in the charge transport layer of the present invention may be cyclohexanone, tetrahydrofuran, dioxolane, dioxane, toluene, xylene, ethyl ether, acetone, ethanol, methyl ethyl ketone, dimethylformamide, ethylene glycol, dimethyl ether, anisole, and so forth. Especially, cyclic ethers, such as
15 tetrahydrofuran, dioxolane, dioxane, and so forth, and aromatic hydrocarbons, such as toluene, xylene, and so forth, and derivatives of such agents are preferable.

[0016]

Surface roughness in the present invention refers to a
20 ten-point-average height of roughness, and more specifically, is defined more specifically, as a difference between an average height of five peaks and an average height of five bottoms existing in a reference length according to JIS B 0601. The ten-point average height of roughness may be measured by using, for example, a surface
25 texture and contour measuring instrument, SURFCOM 1400A (available from Tokyo Seimitsu Co., Ltd.), and so forth.

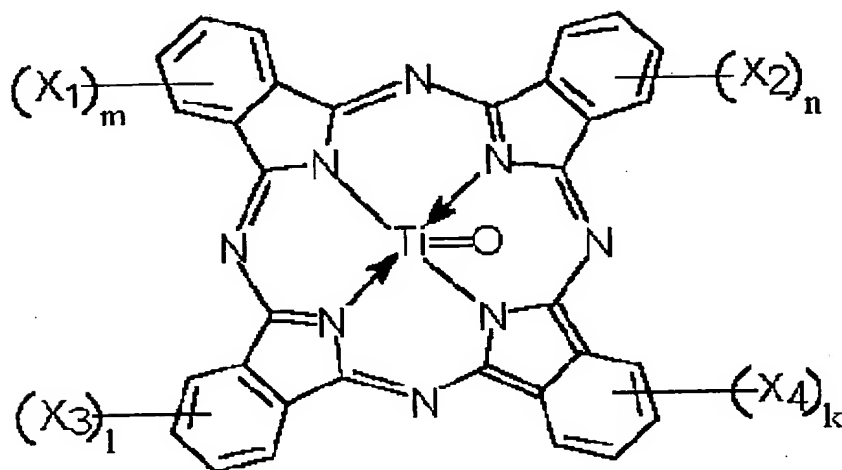
[0017]

The charge generation material used in the present invention may be azo pigments having a carbazole skeleton, triphenylamine
30 skeleton, diphenylamine skeleton, dibenzothiophene skeleton, fluorenone skeleton, oxadiazole skeleton, bisstilbene skeleton, distyryloxadiazole skeleton, distyrylcarbazole skeleton, etc., phthalocyanine pigments such as metallo-phthalocyanine,

non-metallo-phthalocyanine, etc., and organic pigments such as a azulonium salt pigment, a methine squarate pigment, a perylene pigment, an anthraquinone or a polycyclic quinone pigment, a quinoneimine pigment, diphenylmethane and triphenylmethane pigments, benzoquinone and naphthoquinone pigments, cyanine and azomethine pigments, an indigoid pigment, a bisbenzimidazole pigment, etc. Such organic pigments may be used alone or in combination of two or more pigments as a compound. Among above listed agents, titanyl phthalocyanine (referred as TiOPc hereinafter) which is metallo-phthalocyanine, having titanium in a central metal is more preferable due to high sensitivity and excellent characteristics.

[0018]

[Formula 1]



Each of X₁, X₂, X₃, and X₄, and n, m, l, and k, in formula 1 individually represents a halogen atom, and integer numbers 0 to 4, respectively.

[0019]

Japanese Patent Application Laid-Open No.sho57-148745, Japanese Patent Application Laid-Open No.sho59-36254, Japanese Patent Application Laid-Open No.sho59-44054, Japanese Patent Application Laid-Open No.sho59-31965, Japanese Patent Application Laid-Open No.sho61-239248, Japanese Patent Application Laid-Open No.sho62-67094, and so forth are example documents of a TiOPc

synthesis method, or an electrophotographic characteristic. TiOPc is known as having various crystal systems, and Japanese Patent Application Laid-Open No.sho59-49544, Japanese Patent Application Laid-Open No.sho59-41616959, Japanese Patent Application Laid-Open No.sho61-239248, Japanese Patent Application Laid-Open No.sho62-67094, Japanese Patent Application Laid-Open No.sho63-366, Japanese Patent Application Laid-Open No.sho63-116158, Japanese Patent Application Laid-Open No.sho63-196067, Japanese Patent Application Laid-Open No.sho61-17066, Japanese Patent Application Laid-Open No.2001-19871, and so forth describe TiOPc having various crystal forms.

Among the crystal forms, a type of TiOPc which reaches the maximum peak at a Bragg angle 2θ of 27.2° , exhibits an excellent sensitivity characteristic, and is preferably used. Especially, as stated in Japanese Patent Application Laid-Open No.2001-19871, by using a type of TiOPc reaching the maximum peak at 27.2° , reaching primary peaks at 9.4° , 9.6° , and 24.0° , reaching the maximum peak at a lowest angle of 7.3° , and reaching no maximum peak at an angle range of 7.4° to 9.4° , an electrophotographic photoconductor having stable properties, such as no sensitivity loss and no chargeability degradation may be obtained. In addition, among the crystal forms noted above, using a crystal form which has no maximum peak at 26.3° further enhances an effect of the present invention.

[0020]

As a synthesis method using a TiOPc crude, Japanese Patent Application Laid-Open No.Hei6-239769 describes a method in which no halogenated titanium is used. A most beneficial aspect of the method is that a compound of TiOPc crude does not lead to halogenation. If halogenated titanium is included as an impurity of TiOPc, an adverse effect is often observed. Specifically, a static characteristic of a given photoconductor exhibits declined optical sensitivity and chargeability (Japan Hardcopy '89, Manuscripts p.

103 (1989)). TiOPc, free of halogenation as described in Japanese Patent Application Laid-Open No.2001-19871, is focused also in the present invention, and such material is effectively used. From such viewpoint, the present invention is distinguished from technologies involving halogenated TiOPc discussed in documents such as Japanese Patent Application Laid-Open No.2001-115054, etc. in terms of a structure and manifestation of an effect.

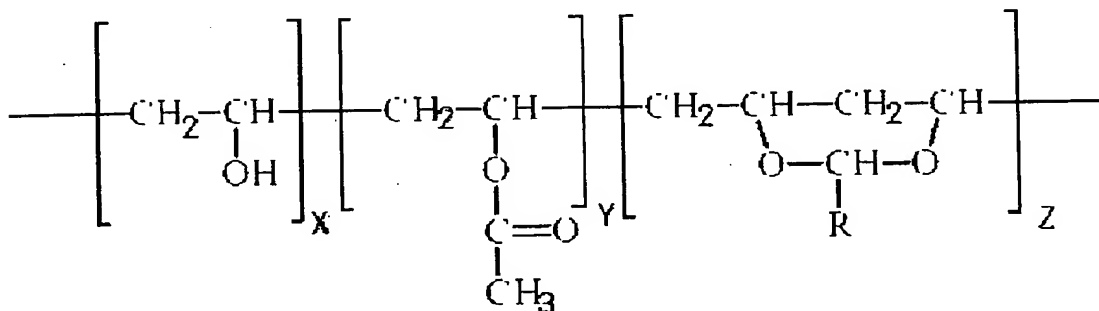
[0021]

A binder resin used for the charge generation layer of the present invention is preferably, polyvinyl acetal such as polyvinyl formal, polyvinyl butyral, and so forth, and a polyvinyl acetal resin having a ratio of weight-average molecular weight (Mw) to an amount of number-average molecular weight (Mn) of 2.2 or more. A polyvinyl acetal resin having an amount of number-average molecular weight of 100,000 or more by polystyrene conversion is further preferable.

Characteristics of the polyvinyl acetal resin are distinguished by a degree of polymerization, and characteristics of a hydroxyl group and an acetyl group are distinguished by a degree of acetalization. A polyvinyl acetal resin having a structure in which the degree of polymerization is 500 to 5000, and the hydroxyl group is 25 mol % to 40 mol % are preferable, with a further preference for a structure having the degree of polymerization of 1000 to 5000, and the hydroxyl group of 30 mol % to 36 mol %.

[0022]

[Formula 2]



X, Y, and Z in formula 2 refers to compositional ratios, and are expressed by formulae $X + Y + Z = 1$, $0.25 \leq X \leq 0.40$, $0 \leq Y \leq 0.1$,

and $0.60 \leq Z \leq 0.75$. R in the formula 2 refers to a hydrogen atom or an alkyl group.

[0023]

A method for computing an average particle diameter of the charge generation material used in the present invention may be a method by which a coated film formed by applying a dispersed liquid is observed with an electron microscope. A particle form of the charge generation material may be a riziform, a needle form, or other various forms, and any form is acceptable. Therefore, to compute the average particle diameter, lengths of the various forms of particles (at least 10 or more) in a longitudinal direction are measured by a direct observation, and then an arithmetic average is computed.

[0024]

In a case where the halogen-free solvent as described above is used in the present invention as the coating solvent for the charge transport layer, a factor for attaining the electrophotographic photoconductor having no sensitivity decline in initial use, and with repeated use, and excelling in chargeability is not clear. However, following factors are assumed to be effective.

[0025]

The charge generation layer is mainly formed of a charge generation material, and a resin, and the resin is formed around a particle of the charge generation material (or absorbed in some cases). Hence, contact between the particles of the charge generation materials is prevented and therefore, aggregation is avoided. When the charge transport layer is applied, surface energy of the resin alters by a solvent in the coating agent, and adhesion of an electroconductive support body forming a bottom of the charge generation layer, or adhesion between a middle layer and charge generation material temporarily separates from the electroconductive support body, or the middle layer, causing the

charge generation material to be aggregated. A reason for the aggregation is unknown, and since the aggregation is especially apparent when a halogen-free solvent is used, use of the halogen-free solvent is considered to be problematic. Generation of aggregation is also likely when a charge generation material having small particles is used. Due to expansion of a specific surface area of an absorption resin, a dramatic change in the surface energy occurs and therefore, aggregation is easily generated.

[0026]

If the charge generation material aggregates in the charge generation layer, photocarrier generation faces two disadvantages. One of the disadvantages is that an increase in a migration distance between an inside (vicinity of a core) of the charge generation material particle which is a carrier generation site, and a particle surface which is a carrier injection site (site where charge is transferred to the charge transport material from the charge generation material) when aggregation occurs. Consequently, a chance of deactivation of most of photocarriers generated in the inside of the charge generation material particle before reaching the carrier injection site on the particle surface increases (decline in photocarrier generation). One more disadvantage is a decrease in effectiveness of photocarrier injection due to decline in the charge transport material surrounding the surface of the charge generation material particle because, as a particle size increases, a surface area declines. By either disadvantage, the aggregation adversely affects the overall photocarrier generation, and decline in optical sensitivity or an increase in residual potential may be caused as a result.

[0027]

In the present invention, to solve a problem related to aggregation of the charge generation material, the average particle diameter of the charge generation material is reduced to a size smaller than surface roughness of the electroconductive support

body, and consequently, elimination of causes leading to aggregation is made possible. When there is unevenness on a surface of a lower layer (electroconductive support body or middle layer) of the charge generation layer, the charge generation layer with a part having a concave shape is considered less likely to migrate to a surrounding by going over a part having a convex shape (intensive migration in the resin). Thus, reducing the average particle diameter of the charge generation material used for the charge generation layer to a size smaller than the surface roughness of the lower layer of the charge generation layer is believed to prevent particle migration (aggregation).

[0028]

Further, in the present invention, by including a polyvinyl acetal resin having a ratio of the amount of weight-average molecular weight (Mw) to the amount of number-average molecular weight (Mn) of 2.2 or more in the charge generation layer, reduction in causes leading to aggregation is made possible. A reason may be that molecular weight of the resin largely depends on adhesion of the lower layer of the charge generation layer (electroconductive support body or middle layer). More specifically, by using a resin having large molecular weight optimal in terms of optimal electric properties and a configuration, and a polyvinyl acetal resin including a low molecular weight resin excelling in adherence having a wide molecular weight distribution, high sensitivity may be achieved, and aggregation may be prevented.

[0029]

Furthermore, by including the average particle diameter of the charge generation material of the present invention of 0.3 μm or less, and the polyvinyl acetal resin as noted above having an amount of number-average molecular weight Mn of 100,000 or more by polystyrene conversion, aggregation of the charge generation material in the electrophotographic photoconductor may be prevented, and the average of 0.3 μm or less may be maintained. The

electrophotographic photoconductor having particularly high sensitivity with no sensitivity decline with repeated use is assumed to be obtained through such method. In addition, a lower threshold for the average particle diameter of the charge generation material of the present invention is preferably 0.05 μm to 0.2 μm from viewpoints of dispersion safety, and crystallization safety.

[0030]

As a characteristic of the photoconductor having the charge transport layer formed of the halogen-free solvent is known to exhibit excellent chargeability thereby preventing an image failure such as background fog, etc. A reason may be that such photoconductors are free from chlorine ion which is included in a halogen solvent.

[0031]

The present invention discovers that when an average diameter of the pigment charge generation material, surface roughness of the electroconductive support body or the middle layer, and a binder resin used for the charge generation layer satisfy a certain condition, the electrophotographic photoconductor exhibiting no sensitivity decline in initial use and with repeated use, and excelling in chargeability is obtainable.

[0032]

To obtain the electrophotographic photoconductors of the present invention, roughening a surface forming the charge generation layer is effective. Methods may be, a method forming continuous roughness by cutting a surface of the electroconductive support body with a cutting tool, a hydro-honing method, a super-finishing method, a wet or dry blasting method, and a roughening method by forming an anodic oxidation coated film. Without roughening, an advantage of the present invention is not obtainable, nevertheless, excessive roughening may disrupt formation of the charge generation layer. Hence, roughness of the surface of the support body is preferably 0.1 μm to 2 μm , and more preferably 0.3 μm to 1.5 μm .

[0033]

Further, to improve the adherence and a coating ability of the charge generation layer, and chargeability of the photoconductor, a method in which a middle layer is formed between the electroconductive support body and the charge generation layer is also effective. Furthermore, by forming the middle layer including an inorganic pigment, a dispersed white dispersion pigment in particular, the middle layer scatters incoming light thereby effectively preventing interference stripes, etc. In addition, forming a middle layer of large thickness may exert a smoothing effect on the surface. In the case, artificial force is applied when the middle layer is being coated so that roughness on the middle layer is effectively increased. More specifically, by a dip coating method, the surface of the middle layer is roughened with vibration given to a surface of a coating solvent while lifting the electroconductive support body. A means of vibrating the surface of the coating solvent may be an ultrasonic generator, a stirrer, and so forth.

[0034]

Other methods such as a method of vibrating the electroconductive support body with a motor, etc., and a method of roughening by blowing air on the middle layer immediately after coating may also be used.

[0035]

A method in which the surface is roughened by forming a Benard cell structure on the middle layer may also be used. The Benard cell structure refers to a procedure in which a rough surface such as a surface called "orange peel" is formed on a surface of the coated film. When a film having the Benard cell structure is formed on the coated film, the coating ability of an upper layer may be lost, and quality of the coated film may be degraded. Hence, a means for preventing formation of the structure is normally employed. However, the present invention positively uses the structure. Basic formation of the Benard cell structure occurs due to a convection

current caused by a difference in a physical property between an inside of the wet coated film and the surface. As a result, a geometric pattern is formed on the surface of the dry coated film. Conditions in which the convection current is likely to be formed are as follows.

1. An evaporation rate of the solvent in the coating solvent for forming the coated film is large,
2. A particle size distribution of particles dispersed in the coating solvent for forming the coated film is wide,
3. Thickness of the coated film in a wet condition (moistened condition) is large after coating,
4. Viscosity of the coated film is low after coating,
5. Surface tension of the coated film is large after coating,
6. Concentration of vapor in a coating atmosphere is low, and
7. Temperature of the coating atmosphere is high.

Forming the middle layer under the above listed conditions is a simple and effective means as obtaining desired roughness is possible.

[0036]

As in the electroconductive support body, roughening the surface of the middle layer is effective in the present invention. However, excessive roughening may severely disrupt formation of the charge generation layer. Hence, roughness of the surface of the support body is preferably 0.1 μm to 2 μm and more preferably 0.3 μm to 1.5 μm .

[0037]

The present invention also requires the charge generation layer formed of a polyvinyl acetal resin having a ratio of weight-average molecular weight (Mw) to number-average molecular weight (Mn) of 2.2 or more, preferably 2.6 or more as determined by molecular weight distribution measured with GPC (Gel Permeation Chromatograph). The polyvinyl acetal resin having an amount of number-average molecular weight of 100,000 or more by polystyrene conversion exhibits an

excellent characteristic, and therefore is preferable. The molecular weight distribution may not necessarily be a normal distribution, and a case having a plurality of molecular peaks is also preferably used.

5 [0038]

[Description of the Preferred Embodiments].

An electrophotographic photoconductors used in the present invention is described in detail with reference to figures below.

Fig. 1 is a cross-sectional view of an example structure of the
10 electrophotographic photoconductor according to the present invention. The figure shows a layered structure in which a charge generation layer 35 mainly formed of a charge generation material, and a charge transport layer 37 mainly formed of a charge transport material are formed on an electrophotographic support body 31.

15 Fig. 2 is a different cross-sectional view of an example structure of the electrophotographic photoconductor according to the present invention. The figure shows a layered structure in which a middle layer 33, the charge generation layer 35 mainly formed of the charge generation material, and a charge transport layer 37 mainly formed
20 of a charge transport material are formed on the electrophotographic support body 31.

[0039]

The electroconductive support body 31 may be film, cylindrically shaped plastic, or paper covered with a conductive material having
25 a volume receptivity of $10^{10} \Omega \text{ cm}$ or less, for example, metal, such as aluminum, nickel, chromium, nichrome, copper, gold, silver, platinum, and so forth, and metal oxide such as tin oxide, indium oxide, and so forth by evaporation coating or sputtering. Alternatively, the electroconductive support body 31 may be plate
30 of aluminum, aluminum alloy, nickel stainless steel, and so forth, and formed into a tube by extension, drawing, etc. An endless nickel belt and an endless stainless belt are disclosed in Japanese Patent Application Laid-Open No.sho52-36016, and may be used once the

surface is roughened.

[0040]

The electrophotographic photoconductor may dispose a middle layer between the electroconductive support body 31 and the charge generation layer. The middle layer mainly formed of resins, and the resins preferably have high resistance to general organic solvent since a solvent is coated on the resins to form a charge generation layer. The resins may be a water soluble resin such as polyvinyl alcohol, casein, polysodium acrylate, and so forth, an alcohol soluble resin such as copolyamide, methoxymethylated polyamide, and so forth, and a curable resin forming a three-dimensional network such as polyurethane, a melamine resin, a phenol resin, an alkyd-melamine resin, an epoxy resin, and so forth. The middle layer may further include a fine power pigment of metal oxide such as titanium oxide, silica, alumina, zirconium oxide, tin oxide, indium oxide, and so forth for preventing interference stripes, and for reducing residual potential.

[0041]

The middle layer may be formed by using an appropriate solvent, and a coating method introduced for formation of the photoconductive layer above. The middle layer may be formed by using an appropriate solvent, and a coating method introduced for formation of the photoconductive layer above. As described above, the surface of the middle layer is roughened, and giving mechanical vibration during middle layer formation, and the formation carried out under conditions for the Benard cell to be formed are effective means in the present invention. Further, for the middle layer of the present invention, a silane coupling agent, a titanium coupling agent, a chromium coupling agent, and so forth may be used. Additionally, for the middle layer of the present invention, a layer formed by anodic oxidation of Al_2O_3 , and a layer formed by a vacuum film generation method for an organic substance such as poly-p-xylylene (parylene), and an inorganic substance such as SiO_2 ,

SnO₂, TiO₂, ITO, CeO₂, and so forth may be used. Alternatively, a publicly known layer may also be used. The middle layer with thickness of 0 μm to 5 μm is appropriate.

[0042]

5 The photoconductive layer is described in detail below. The photoconductive layer of a layered structure having the charge generation layer 35, and the charge transport layer 37 exhibits excellent characteristics in terms of sensitivity and durability, and is preferably used.

10 The charge generation layer 35 is the charge generation material mainly formed of the organic pigments as described above. The charge generation layer may be formed by dispersing the organic pigment and the polyvinyl acetal resin in an appropriate solvent. Then a resulting agent is applied to the electroconductive support body
15 and dried as described above.

[0043]

The solvent used may be a halogen-free solvent such as isopropanol, acetone, methyl ethyl ketone, cyclohexanone, tetrahydrofuran, dioxane, ethyl cellosolve, ethyl acetate, methyl acetate,
20 cyclohexane, toluene, xylene, ligroin, and so forth, and a ketone solvent, an ester solvent, an ether solvent, and so forth are particularly preferred.

[0044]

As a dispersion method, the coating solvent is dispersed in a
25 ball mill, a vibration mill, a disc vibration mill, an attritor, a sand mill, a paint shaker, a jet mill, an ultrasonic disperser, and so forth by which the crude powdery pigment as described above is dispersed in a dispersion solvent. Alternatively, a pulverization method by applying mechanical energy such as
30 compression, shearing, attrition, friction, elongation, impact, vibration, and so forth to a pigment may be also used.

An important finding in which molecular weight of the polyvinyl acetal resin decreases when the organic pigment as described above

is thoroughly dispersed with the polyvinyl acetal resin in a solvent to form the charge generation material is obtained in the present invention. To compensate, a polyvinyl acetal resin having a ratio (Mw/Mn) of weight-average molecular weight (Mw) to number-average molecular weight (Mn) of 2.2 or more, preferably 2.6 or more, and having number-average molecular weight (Mn) of 100,000 or more by polystyrene conversion is preferably used.

[0045]

As a coating method, a coating solvent may be applied by an impregnation coating method, spray coating, beat coating, nozzle coating, spinner coating, ring coating, and so forth. The charge generation layer 35 with the thickness of roughly 0.01 μm to 5 μm is appropriate, and 0.1 μm to 2 μm is preferable. The electrophotographic photoconductor of the present invention exhibits high sensitivity even when the thickness is 0.2 μm or less, and an optimal chargeability characteristic of such electrophotographic photoconductor is obtained.

[0046]

To form the charge transport layer 37, the charge transport material, and the binder resin are melted and dispersed in a halogen-free solvent, preferably, cyclic ether such as tetrahydrofuran, dioxolane, dioxane, and so forth, an aromatic hydrocarbon such as toluene, and xylene, and a derivative thereof, and then a resulting agent is applied to the charge generation layer and dried as described above.

[0047]

The charge transport material may be a positive opening transport material, or an electron transport material. The electron transport material may be, for example, an electron acceptor such as chloranyl, bromanyl, tetracyanoethylene, tetracyanoquinodimethane, 2,4,7-trinitro-9-fluorenone, 2,4,5,7-tetranitro-9-fluorenone, 2,4,5,7-tetranitroxanthone, 2,4,8-trinitrothioxanthone, 2,6,8-trinitro-4H-indeno[1,2-b] thiophene-4-on,

1,3,7-trinitrodibenzothiophene-5,5-dioxide, a benzoquinone derivative, and so forth.

[0048]

The positive opening transport material may be
5 poly-N-vinylcarbazole and a derivative thereof, poly-y-carbazole
ethyl glutamate and a derivative thereof, pyrene-formaldehyde
condensate and a derivative thereof, polyvinyl pyrene, polyvinyl
phenanthrene, polysilane, an oxazole derivative, an oxadiazole
derivative, an imidazole derivative, a monoarylamine derivative,
10 a diarylamine derivative, a triarylamine derivative, a stilbene
derivative, an α -phenylstilbene derivative, a benzidine derivative,
a diarylmethane derivative, a triaryl methane derivative, a
9-styranthracene derivative, a pyrazoline derivative, a
divinylbenzene derivative, a hydrazone derivative, an indene
15 derivative, a butadiene derivative, a pyrene derivative,
bisstilbene derivative, an enamine derivative, and so forth, and
other known materials. The materials maybe used alone, or in
combination of two or more materials.

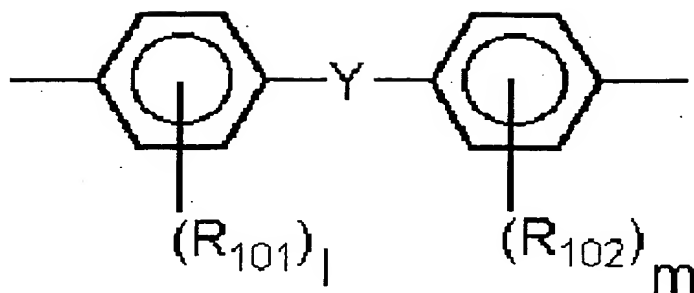
[0049]

20 The binder resin may be a thermoplastic resin or a heat-curable
resin, such as polystyrene, a styrene-acrylonitrile copolymer, a
styrene-butadiene copolymer, a styrene-maleic anhydride copolymer,
polyester, polyvinyl chloride, a vinyl chloride-vinyl acetate
copolymer, polyvinyl acetate, polyvinylidene chloride,
25 polyarylate, a phenoxy resin, polycarbonate, a cellulose acetate
resin, an ethyl cellulose resin, polyvinyl butyral, polyvinyl
formal, polyvinyl toluene, poly-N-vinylcarbazole, an acrylic resin,
a silicone resin, an epoxy resin, a melamine resin, an urethane
resin, a phenol resin, an alkyd resin, and so forth. Polycarbonate
30 especially exhibits excellent characteristics in terms of
chargeability or abrasion resistance.

[0050]

An amount of the charge transport material is 20 to 300 parts

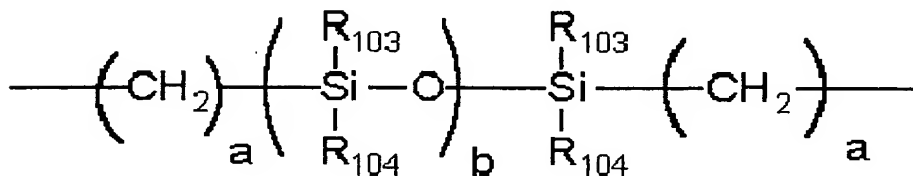
[Formula 4]



In formula 4, each of R₁₀₁, and R₁₀₂ individually represent a substituted or an unsubstituted alkyl group, an aryl group, or a halogen atom. In the formula, l, and m are integer numbers 0 to 4, Y is a single bond, straight chain branched or cyclic alkylene group having carbon atom numbers 1 to 12, and expressed by -O-, -S-, -SO-, -SO₂-, -CO-, -CO-O-Z-O-CO (Z in the figure represents an aliphatic divalent group), or formula 5

[0054]

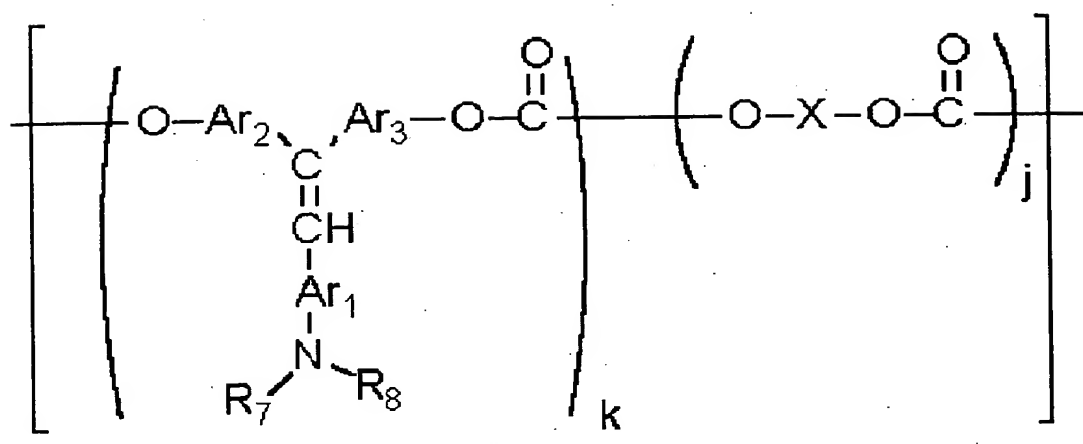
[Formula 5]



(In the formula, a, and b represent integer numbers 1 to 20, and 1 to 2000, respectively, and R₁₀₃, and R₁₀₄ represent substituted or unsubstituted alkyl groups or aryl groups). R₁₀₁, and R₁₀₂, and R₁₀₃, and R₁₀₄ in the figure may be identical to, or different from each other.

[0055]

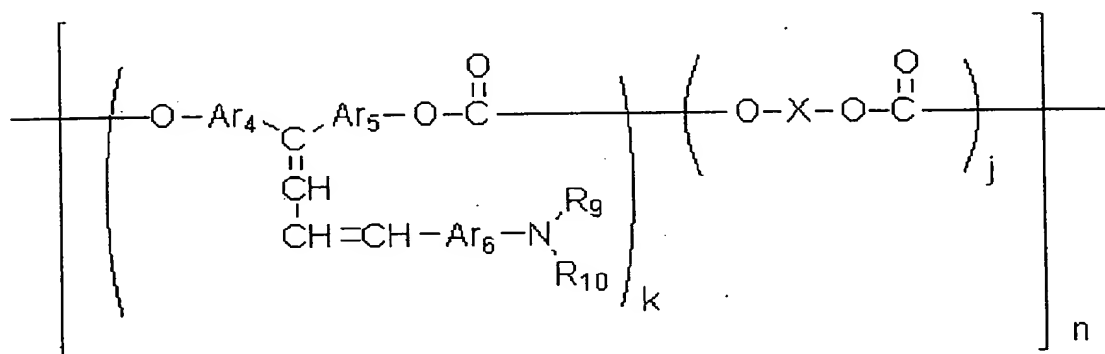
[Formula 6]



In formula 6, each of R₇, and R₈, represents a substituted aryl group or an unsubstituted aryl group. Each of Ar₁, Ar₂, and Ar₃ represents an allylene group identical to, or different from each other. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0056]

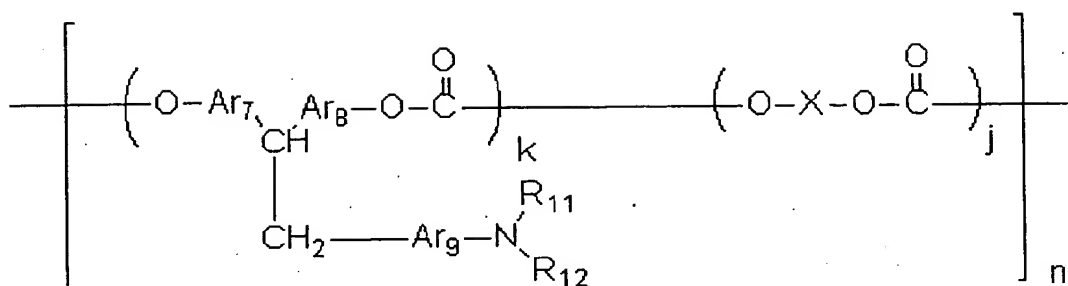
[Formula 7]



In formula 7, each of R₉, and R₁₀ represents a substituted aryl group or an unsubstituted aryl group. Each of Ar₄, Ar₅, and Ar₆ represents an allylene group identical to, or different from each other. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0057]

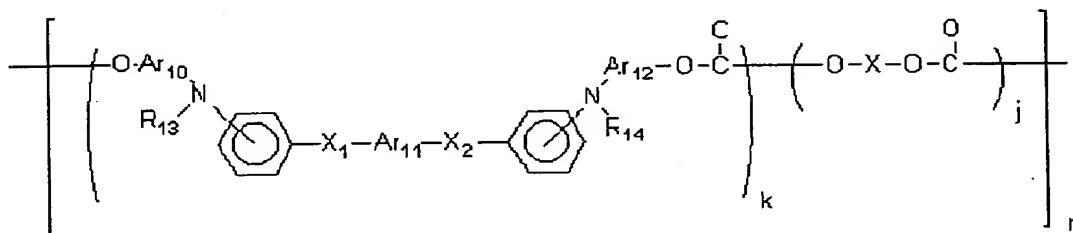
[Formula 8]



In formula 8, each of R₁₁, and R₁₂ represents a substituted aryl group or an unsubstituted aryl group. Each of Ar₇, Ar₈, and Ar₉ represents an allylene group identical to, or different from each other. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0058]

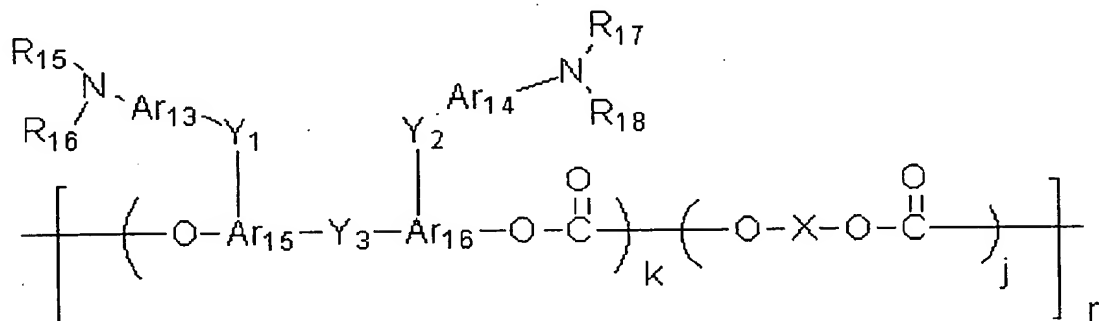
[Formula 9]



In formula 9, each of R₁₃, and R₁₄ represents a substituted aryl group or an unsubstituted aryl group. Each of Ar₁₀, Ar₁₁, and Ar₁₂ represents an allylene group identical to, or different from each other. X₁, and X₂, are a substituted ethylene group or an unsubstituted ethylene group, or a substituted vinylene group or an unsubstituted vinylene group. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0059]

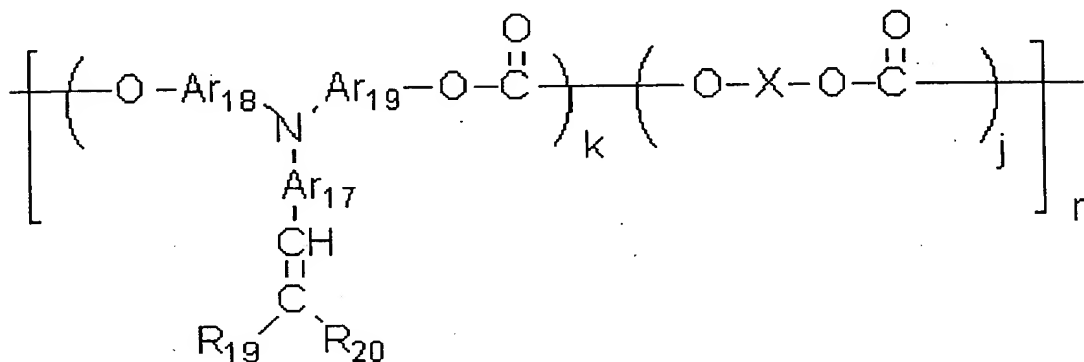
[Formula 10]



In formula 10, each of R15, R16, R17, and R18 represent a substituted aryl group or an unsubstituted aryl group. Each of Ar13, Ar14, Ar15, and Ar16 represents an allylene group identical to, or different from each other. Y1, Y2, and Y3 are a single bond substituted cycloalkylene group or a single bond unsubstituted cycloalkylene group, a substituted alkylene ether group or an unsubstituted alkylene ether group, an oxygen atom, a sulfur atom, or a vinylene group, and may be identical to, or different from each other. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0060]

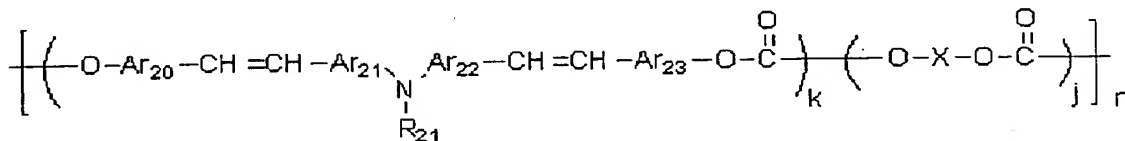
[Formula 11]



In formula 11, each of R19, and R20, represents a hydrogen atom, or a substituted aryl group or an unsubstituted aryl group, and may form a ring. Each of Ar17, Ar18, and Ar19 represents an allylene group identical to, or different from each other. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0061]

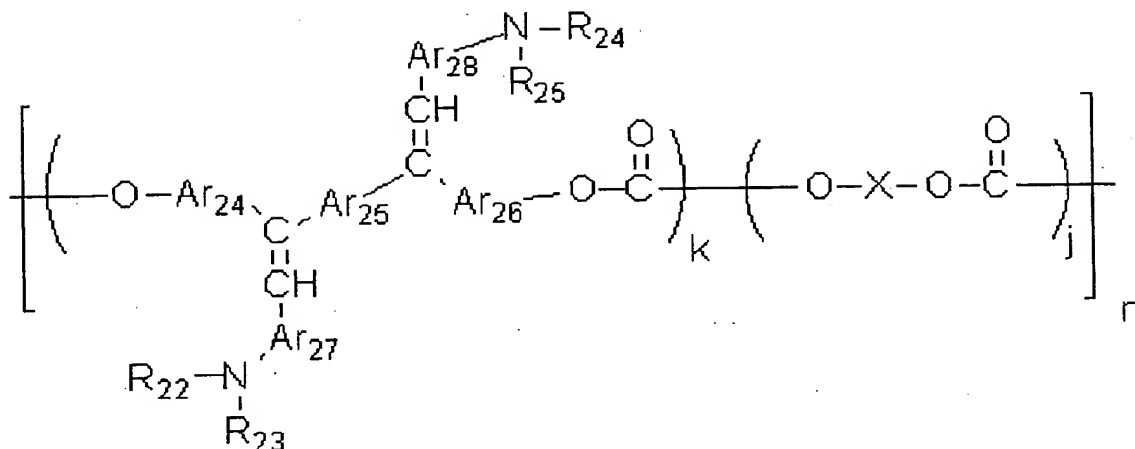
[Formula 12]



In formula 12, R21 represents a substituted aryl group or an unsubstituted aryl group. Each of Ar20, Ar21, Ar22, and Ar23 represents an allylene group identical to, or different from each other. X, k, j, and n are identical to X, k, j, and n in the formula 2.

[0062]

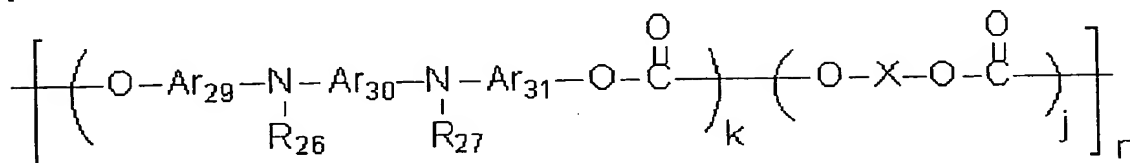
[Formula 13]



In formula 13, each of R₂₂, R₂₃, R₂₄, and R₂₅ represents a substituted aryl group or an unsubstituted aryl group. Each of Ar₂₄, Ar₂₅, Ar₂₆, Ar₂₇, and Ar₂₈ represents an allylene group identical to, or different from each other. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0063]

[Formula 14]



In formula 14, each of R₂₆, and R₂₇ represents a substituted or an unsubstituted aryl group. Each of Ar₂₉, Ar₃₀, and Ar₃₁ represents an allylene group identical to, or different from each other. X, k, j, and n are identical to the X, k, j, and n in the formula 2.

[0064]

The polymer charge transport material used for the charge transport layer may be the polymer charge transport materials as described above. When the film is formed, a polymer having a two-dimensional or a three-dimensional cross-linking structure may also be used once the film of the transport layer is formed through curing or cross-linking as a monomer or an oligomer having an electron-donating group.

The charge transport layer formed of copolymers having the

electron-donating group, and the polymer having the cross-linking structure excel in abrasion resistance. Normally, an electrostatic potential (potential of an unexposed portion) is constant during an electrophotographic process. Thus, as a surface layer of the photoconductor is abraded with repeated use, electric field intensity applied to the photoconductor increases. With the increase of the electric field intensity, occurrence of background deposition also increases, and therefore, using photoconductor having high abrasion resistance is preferable in terms of the background deposition. The discharge transport layer formed of copolymers having the electron-donating groups is a polymer compound, and excels in forming a film, and superior to a charge transport layer formed of a low-molecular weight component because a charge transport site of high density may be structured. Therefore, rapid responsiveness is expected from the photoconductor having the charge transport layer using the polymeric charge transport material.

[0065]

Other copolymers having the electron-donating group may be a publicly known copolymer, a block polymer, a graft polymer, and a star polymer. Alternatively, cross-linked polymers having the electron-donating group as described in, for example, Japanese Patent Application Laid-Open No.Hei3-109406, Japanese Patent Application Laid-Open No.2000-206723, Japanese Patent Application Laid-Open No.2001-34001, and so forth may also be used.

[0066]

A plasticizer or a leveling agent may be added to the charge transport layer 37 of the present invention. An ordinary plasticizer such as dibutyl phthalate, dioctyl phthalate, and so forth, may be used for the plasticizer of the present invention, and an appropriate amount used is approximately 0 % to 30 % by weight of the binder resin. The leveling agent may be silicon oil such as dimethyl silicone oil, methyl phenyl silicone oil, and an

appropriate amount used is approximately 0 % to 1 % by weight of the binder resin.

[0067]

The electrophotographic photoconductor of the present invention
5 may further dispose a protection layer on the photoconductive layer for a purpose of protecting the photoconductive layer. With a recent increase in computer daily use, high speed printer output as well as a downsized apparatus are demanded. Therefore, the protection layer is disposed, and durability is improved so that the
10 photoconductor of the present invention having high sensitivity, and no defects is effectively used.

[0068]

A material used for the protection layer may be, a resin such as ABS resin, ACS resin, an olefine-vinyl monomer copolymer, a
15 chlorinated polyether, an aryl resin, a phenol resin, polyacetal, polyamide, polyamidoimide, polyacrylate, polyallyl sulfone, polybutylene, polybutylene terephthalate, polycarbonate, polyarylate, polyethersulfone, polyethylene, polyethylene terephthalate, polyimide, an acrylic resin, polymethylpentene,
20 polypropylene, polyphenylene oxide, polysulfone, polystyrene, an AS resin, a butadiene-styrene copolymer, polyurethane, polyvinyl chloride, polyvinylidene chloride, an epoxy resin, and so forth, a fluorocarbon resin, such as polytetrafluoroethylene and so forth, silicone resin, and so forth. Alternatively, such resin containing
25 a dispersed titanium oxide, aluminum oxide, tin oxide, zinc oxide, zirconium oxide, magnesium oxide, potassium titanate, silica, and such materials having a dispersed inorganic material thereon.

[0069]

Having the protection layer is an effective means for obtaining
30 high responsiveness, and protecting from reduced residual potential since the charge transport material may be added to the protection layer. The charge transport material used as the protection layer may be the charge transport material, or the polymer charge

transport material as explained above for the charge transport layer. A general coating method is employed for formation of the protection layer. The protection layer with thickness of approximately 0.1 μm to 10 μm is appropriate. Alternatively, a protection layer formed of a publicly known material such as a-C, a-SiC, and so forth through the vacuum film generation method may also be used.

[0070]

An image forming apparatus of the present invention is described in detail with reference to figures.

10 Fig. 3 is a schematic illustrating an electrophotographic process, and the image forming apparatus of the present invention. According to the present invention, a modification as described below is also permitted.

[0071]

15 Fig. 3 shows a photoconductor 1 in which the photoconductive layer having at least the charge generation layer, and the charge transport layer on the electroconductive support body. The photoconductor 1 may be a drum shaped, and may also be formed of a sheet, an endless belt. A known means such as a corotron, a scorotron, a solid state charger, a charge roller, a transfer roller, and so forth is used for a charge roller 3, a pre-transfer charger 7, transfer charger 10, a separation charger 11, and a pre-cleaning charger 13.

[0072]

25 As a charge system, a close spacing method, such as a contact charge system, or a non-contact charge system is particularly preferable. The contact charge system has beneficial factors such as high chargeability, little ozone generation, and also the apparatus may be downsized.

30 A charge member used in the contact system refers to a type which a surface of the charge member contacts a surface of the photoconductor, and may be in a form of a charge roller, a charge blade, or a charge brush. Among such forms, the charge roller, and

the charge brush are preferably used.

[0073]

A closely spaced charge member is a type which is closely positioned in a non-contact manner such that a 200 μm gap is left
5 between the surfaces of the photoconductor, and the charge member. Such a distance of the gap distinguishes the charge member from publicly known charge members such as the corotron, and the scorotron. The closely spaced charge member in the present invention may be in any form if the gap with the surface of the photoconductor
10 is adequately controlled. For example, by mechanically fixing a rotation axis of the photoconductor and the charge member, a suitable gap may be obtained.

[0074]

Methods used for readily stabilizing the gap and maintaining a
15 given gap are as follows. One of the method is that the charge member in a form of the charge roller is used to arrange a gap forming member in both ends of a non-image forming element of the charge member, and the surface of the photoconductor is contacted only by the both ends so that an image forming area is arranged in a
20 non-contact manner. An alternative method is that the gap forming member is positioned in both ends of a photoconductive non-image forming element, and the surface of the charge member is contacted only by the ends so that the image forming area is arranged in a the non-contact manner. Methods described in Japanese Patent
25 Application Laid-Open No.2001-211448, and Japanese Patent Application Laid-Open No.2001-226432 are particularly preferable. An example of a closely spaced charge mechanism having the gap forming member in the charge member is shown in Fig. 4.

[0075]

30 By using the methods described above, beneficial factors such as high chargeability, and little ozone generation are provided, and the apparatus may be downsized. Further, no deposition of toner, and no mechanical abrasion by contact are generated. Therefore,

such configuration is preferably used.

Furthermore, a superimposed alternating current is preferably applied so that uneven charge is less likely to be generated.

[0076]

5 For a light source such as an image irradiation unit 5, a charge elimination lamp 2, and so forth, a general light emitting device such as a fluorescent lamp, a tungsten lamp, a halogen lamp, a mercury-vapor lamp, sodium lamp, a light emitting diode (LED), a semiconductor laser (LD), an electroluminescence (EL), and so forth
10 may be used.

To irradiate only light of a desired wavelength band, various filters such as a sharp cut filter, a band pass filter, a near-infrared cut-off-filter, a dichroic filter, an interference filter, a color conversion filter, and so forth may be used.

15 [0077]

Among the light sources, a light emitting diode, and a semiconductor laser have high irradiation energy, and a wavelength of 600 nm to 800 nm causing a phthalocyanine pigment used in the charge generation material to exhibit high sensitivity. Therefore,
20 such light sources are preferably used.

In addition to the processes illustrated in Fig. 3, having a process such as a transfer process, a charge elimination process, a cleaning process, or a pre-irradiation process, causes the light sources, etc. to irradiate the photoconductor.

25 [0078]

Toner developed on the photoconductor 1 is transferred to a transfer sheet 9 by a development unit 6. However, whole toner is not transferred, and some toner resides on the photoconductor 1. Such toner is removed from a photoconductor by a fur brush 14, and
30 a blade 15. In some apparatuses, cleaning may be performed only by a cleaning brush, and a publicly known brush such as a fur brush, a magnetic fur brush, and so forth may be used.

[0079]

When the electrophotographic photoconductor is positively (negatively) charged and image exposure is performed, a positive (negative) electrostatic latent image is formed on the surface of the photoconductor. If such image is developed with toner (charge-seeking particulate) of negative (positive) polarity, a positive image is obtained. Likewise, if the image is developed with toner of positive (negative) polarity, a negative image is obtained.

Publicly known means apply to a development means, and a charge elimination means.

[0080]

The image forming apparatus as described above may be fitted in a copier, a facsimile, or a printer. Alternatively, the image forming apparatus may be configured in such apparatuses as a form of a process cartridge. The process cartridge is a device (unit) including an inbuilt photoconductor, and also the charge means, the exposure means, the development means, the transfer means, a cleaning means, and a charge-eliminating means. The process cartridge may take a number of forms, and Fig. 5 shows a general example.

[0081]

[Embodiments]

Although the present invention is explained below with reference to embodiments, the present invention is not limited by such embodiments. Note that parts described all denote parts by weight.

A molecular weight distribution of a polyvinyl acetal resin of the present invention is determined by GPC under following conditions.

[0082]

Molecular weight distribution determined by GPC

Measuring device: SC-8010 System available from Tosoh Corporation

Column: Shodex KF-800D, and KF-805L available from

Showa Denko K. K.

Eluent: THF

Temperature: column thermostat oven, 40 °C

Flow rate: 1.0 ml/min

5 Injection amount: 100 µl

Detector: differential refractive index detector (RI)

A composition sample of the charge generation material used in the present invention is described below.

[0083]

10 <Composition sample>

Twenty-nine point two grams of 1,3-diiminoisoindoline, and 200 ml of sulfolane are composed, and 20.4 g of titanium tetrabutoxide is dropped under a nitrogen gas flow. Once completed, temperature of the composition is gradually raised to 180 °C, and the composition is mixed for 5 hours while keeping a reaction temperature of 170 °C to 180 °C to gain reaction. On completion of reaction, the composition is left to cool down, and precipitate is filtered out. Chloroform is used for a wash until fine particles turn blue, and then methanol is used for several washes. Further, hot water of 80 °C is used for several more washes. Once dried, crude titanyl phthalocyanine powder is yielded. The crude titanyl phthalocyanine is dissolved in 20 parts concentrated sulfuric acid, and dropped in 100 parts iced water while mixing to deposit crystals. The crystals are filtered, and repeatedly washed until a washing agent is neutral so that a wet cake of titanyl phthalocyanine pigment is yielded. Two grams of the wet cake is mixed in 20 g of tetrahydrofuran, and composed for 4 four hours.

The composition is added by 100 g of methanol, and mixed for 1 hour. Once filtered, and dried, titanyl phthalocyanine powder of the present invention is yielded. The titanyl phthalocyanine powder is tested by using an X-ray diffraction spectrum under a condition described below. As a result, the titanyl phthalocyanine which reaches a maximum peak at a Bragg angle 2θ of $27.2^\circ \pm 0.2^\circ$, reaches

a peak at a lowest Bragg angle of $23^{\circ} \pm 0.2^{\circ}$, and has no maximum peak at a range of 7.4° to 9.4° , for Cu- $k\alpha$ radiation (wave length of 1.542\AA) is obtained. A result is shown in Fig. 6.

[0084]

5 (Test condition for X-ray diffraction spectrum)

X-ray tube: Cu
Voltage: 50 kV
Current: 30 mA
Scanning speed: $2^{\circ}/\text{min}$
10 Scanning range: 3° to 40°
Time constant: 2 seconds

[0085]

(Sample 1)

Roughening processing by cutting is applied until surface
15 roughness is $1.0\text{ }\mu\text{m}$. A coating solvent for the charge generation layer of a composition as stated below having an average particle diameter of $0.2\text{ }\mu\text{m}$ dispersed by bead-milling dispersion is applied to an aluminum base pipe having an outer diameter of 30 mm, and length of 340 mm. Then dried at a temperature of 80°C for 20 minutes,
20 and a charge generation layer having thickness of $0.2\text{ }\mu\text{m}$ is formed.

[Coating solvent for the charge generation layer]

Titanyl phthalocyanine pigment of the composition sample: 15 parts

Polyvinyl acetal resin (S-LEC BX-1 available from Sekisui
25 Chemical Co., Ltd.) 7.5 parts (Mw/Mn of 3.1, and Mn of 120,000)
Methyl ethyl ketone: 600 parts

By using a reflection electron microscope (SEM, S-4700 available from Hitachi High-Technologies Corporation), the surface of the yielded charge generation layer is observed at a magnification of
30 50,000 times. Thirty (needle-like shaped) particles of titanyl phthalocyanine powder being observed are arbitrarily selected, and length of each particle is measured. The result shows that the average particle diameter is $0.2\text{ }\mu\text{m}$ which is identical to the

particles found in the coating solvent.

[0086]

Then the charge transport layer coating solvent having the composition as stated below is applied to the charge generation
5 layer, and dried at 130 °C for 20 minutes so that the charge transportation layer having thickness of 25 μm, and the electrophotographic photoconductor is produced.

[Coating solvent for the charge transport layer]

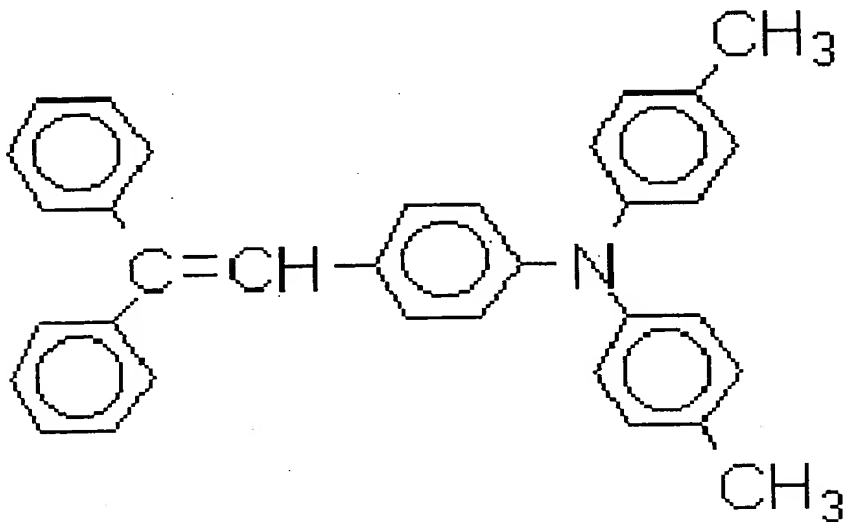
Polycarbonate resin (Iupilon Z200 available from Mitsubishi
10 Engineering-Plastics Corporation): 10 parts

Charge transport material of following Formula 15: 8 parts

Tetrahydrofuran (THF): 80 parts

[0087]

[Formula 15]



15

[0088]

(Sample 2)

The aluminum base pipe of sample 1 is dipped in the coating solvent for a middle layer having a composition as stated below, and then
20 dried at 130 °C for 20 minutes so that a middle layer having thickness of 3 μm is formed. A result shows that surface roughness of a middle layer surface is 0.5 μm.

[Coating solvent for the middle layer]

Titanium oxide (CR-EL, available from Ishihara Sangyo Kaisha

Ltd.): 70 parts

Alkyd resin: 15 parts {Beckolite M6401-50-S available from Dainippon Ink and Chemicals, Inc. (solid content of 50 %)}

Melamine resin: 10 parts {Super Beckamine L-121-60 available from Dainippon Ink and Chemicals, Inc. (solid content of 60 %)}

Methyl ethyl ketone: 100 parts

Using a procedure identical to the sample 1, the charge generation layer, and the charge transport layer are formed, and an electrophotographic photoconductor is produced.

[0089]

(Sample 3)

An electrophotographic photoconductor is produced through the procedure identical to the sample 1 except that the aluminum base pipe is applied with roughening processing by cutting until the surface roughness is 0.3 μm .

[0090]

(Comparative sample 1)

An electrophotographic photoconductor is produced through the procedure identical to the sample 1 except that an aluminum base pipe used is applied with no roughening processing, and has a smooth surface having surface roughness of less than 0.05 μm , the outer diameter of 30 mm, and the length of 40 mm.

[0091]

(Sample 4)

The aluminum base pipe obtained as the sample 1 is dipped in the coating solvent for a middle layer having a composition as stated above for the sample 2. On dipping, the coating solvent is applied with ultrasonic vibration. Then, the aluminum base pipe is dried at 130 °C for 20 minutes so that a middle layer having the thickness of 3 μm is produced. A result shows that the middle layer has surface roughness of 0.8 μm .

Using the procedure identical to the sample 1, the charge generation layer, and the charge transport layer are formed, and

an electrophotographic photoconductor is produced.

[0092]

(Sample 5 and 6, and comparative samples 2 to 4)

Through procedures identical to the procedures applied to the
5 samples 1 to 4, and the comparative samples 2 to 6,
electrophotographic photoconductors of samples 5 and 6, and
comparative samples 2 to 6 are produced using a coating solvent
for the charge generation layer having an average particle diameter
of 0.6 μm dispersed by bead-milling dispersion.

10 [0093]

(Sample 7, and comparative sample 5)

The polyvinyl acetal resin of the sample 1 (S-LEC BX-1 available
from Sekisui Chemical Co., Ltd.)

The polyvinyl acetal resin (Mw/Mn of 3.1, and Mn of 120,000) is
15 dissolved in methyl ethyl ketone, and then ultrasonic vibration
is applied at a frequency of 28 kHz and at 500 W for 1 hour using
an ultrasonic cleaning apparatus so that polyvinyl acetal having
a different molecular weight distribution (Mw/Mn of 2.6, and Mn
of 100,000) is produced. Electrophotographic photoconductors are
20 produced by the procedure identical to the sample 1, and the
comparative sample 1 except that, as described above, a composition
of the coating solvent for the charge generation layer is altered
to the resin as shown below.

[Coating solvent for the charge generation layer]

25 Titanyl phthalocyanine pigment of the composition sample: 15
parts

Polyvinyl acetal resin: 7.5 parts (Mw/Mn of 2.6, Mn of 100,000)

Methyl ethyl ketone: 600 parts

[0094]

30 (Sample 8)

The polyvinyl acetal resin of the sample 1 (S-LEC BX-1, available
from Sekisui Chemical Co., Ltd.) (Mw/Mn of 3.1, and Mn of 120,000)
is dissolved in methyl ethyl ketone, and ultrasonic vibration is

applied at a frequency of 28 kHz and at 500 W for 8 hours using the ultrasonic cleaning apparatus so that a polyvinyl acetal resin having a different molecular weight distribution (Mw/Mn of 2.2, and Mn of 100,000) is produced. An electrophotographic photoconductor is produced by the procedure identical to the sample 4 except that, as described above, a composition of the coating solvent for the charge generation layer is altered to the resin as shown below.

[Coating solvent for the charge generation layer]

10 Titanyl phthalocyanine pigment of the composition sample: 15 parts
Polyvinyl acetal resin: 7.5 parts (Mw/Mn of 2.2, Mn of 100,000)
Methyl ethyl ketone: 600 parts
[0095]

15 (Comparative sample 6)

The polyvinyl acetal resin of the sample 1 (S-LEC BX-1, available from Sekisui Chemical Co., Ltd.) (Mw/Mn of 3.1, and Mn of 120,000) is dissolved in methyl ethyl ketone, and ultrasonic vibration is applied at a frequency of 28 kHz and at 500 W for 24 hours using the ultrasonic cleaning apparatus so that a polyvinyl acetal resin having a different molecular weight distribution (Mw/Mn of 1.9, and Mn of 100,000) is produced. An electrophotographic photoconductor is produced by the procedure identical to the sample 4 except that, as described above, a composition of the coating solvent for the charge generation layer is altered to the resin composed as shown below.

[Coating solvent for the charge generation layer]

30 Titanyl phthalocyanine pigment of the composition sample: 15 parts
Polyvinyl acetal resin: 7.5 parts (Mw/Mn of 1.9, Mn of 100,000)
Methyl ethyl ketone: 600 parts
[0096]

The polyvinyl acetal resin of the sample 1 (S-LEC BX-1, available

from Sekisui Chemical Co., Ltd.) (Mw/Mn of 3.1, and Mn of 120,000) is dissolved in methyl ethyl ketone, and ultrasonic vibration is applied at a frequency of 28 kHz and at 500 W for 72 hours using the ultrasonic cleaning apparatus so that a polyvinyl acetal resin
5 having a different molecular weight distribution (Mw/Mn of 1.8, and Mn of 90,000) is produced. An electrophotographic photoconductor is produced by the procedure identical to the sample 4 except that, as described above, a composition of the coating solvent for the charge generation layer is altered to the resin
10 as shown below.

[Coating solvent for the charge generation layer]

Titanyl phthalocyanine pigment of the composition sample: 15 parts

Polyvinyl acetal resin: 7.5 parts (Mw/Mn of 1.8, Mn of 90,000)

15 Methyl ethyl ketone: 600 parts

[0097]

(Sample 9)

Electrophotographic photoconductors of sample 9, and comparative sample 8 are produced by the procedure identical to
20 the sample 1, and the comparative sample 1, respectively, except that dioxane is used as a solvent for the charge transport layer coating solvent instead of tetrahydrofuran.

[0098]

(Sample 10, and comparative sample 9)

25 Electrophotographic photoconductors of sample 10, and comparative sample 9 are produced by the procedure identical to the sample 1, and the comparative sample 1, respectively, except that 80 parts tetrahydrofuran is replaced by 80 parts tetrahydrofuran, and 30 parts toluene.

30 [0099]

(Comparative sample 10)

An electrophotographic photoconductor is produced by the procedure identical to the sample 1 except that 80 parts

tetrahydrofuran is replaced by 80 parts dichloromethane (MDC).

[0100]

Each of the electrophotographic photoconductors produced is disposed in a process cartridge for an image forming apparatus as shown in Fig. 5. A semiconductor laser of 780 nm is used as an image irradiation means. The image irradiation means is disposed in an image forming apparatus (imagio MF-2200, available from Ricoh Co., Ltd.) having a modification to dispose a closely spaced non-contact roller charger (gap between the photoconductor surface, and the charger surface is 100 μ m). Test printing of A4 100,000 PPC sheets in a longitudinal direction is conducted. Evaluation of images is determined by background fog, image density, and rated as A. good, B. fair, and C. failure. Additionally, a surface potential meter is disposed where a developer is in the image forming apparatus, electric potential VL after irradiation at full emission of the semiconductor laser is also measured. A charging condition is as stated below. Results are shown in table 1.

<Charge condition>

DC bias: -850 V

AC bias: 1.5 kV (peak to peak)

Frequency: 2 kHz

[0101]

[Table 1-1]

	Charge Transport Layer Coating Solvent	Charge Generation Layer Resin	
		Mw/Mn	Mn
Sample 1	THF	3.1	120,000
Sample 2	THF	3.1	120,000
Sample 3	THF	3.1	120,000
Sample 4	THF	3.1	120,000
Sample 5	THF	3.1	120,000
Sample 6	THF	3.1	120,000
Sample 7	THF	2.6	100,000
Sample 8	THF	2.2	100,000
Sample 9	Dioxolane	3.1	120,000
Sample 10	THF/Toluene	3.1	120,000
Comparative sample 1	THF	3.1	120,000
Comparative sample 2	THF	3.1	120,000
Comparative sample 3	THF	3.1	120,000
Comparative sample 4	THF	3.1	120,000
Comparative sample 5	THF	2.6	100,000
Comparative sample 6	THF	1.9	100,000
Comparative sample 7	THF	1.8	90,000
Comparative sample 8	Dioxolane	3.1	120,000
Comparative sample 9	THF/Toluene	3.1	120,000
Comparative sample 10	MDC	3.1	120,000

[0102]

[Table 1-2]

	Average particle diameter (μm)	Surface roughness (μm)	Image evaluation		VL (-V)
			Background	Image density	
Sample 1	0.2	1.0	A	A	90
Sample 2	0.2	0.5	A	A	110
Sample 3	0.2	0.3	B	A	110
Sample 4	0.2	0.8	A	A	100
Sample 5	0.6	1.0	B	B	135
Sample 6	0.6	0.8	B	B	130
Sample 7	0.2	1.0	A	A	100
Sample 8	0.2	0.8	B	A	120
Sample 9	0.2	1.0	A	A	105
Sample 10	0.2	1.0	A	A	95
Comparative sample 1	0.2	-	C	C	170
Comparative sample 2	0.6	0.5	C	B	145
Comparative sample 3	0.6	0.3	C	C	165
Comparative sample 4	0.6	-	C	C	170
Comparative sample 5	0.2	-	C	C	180
Comparative sample 6	0.2	0.8	C	B	150
Comparative sample 7	0.2	0.8	C	C	240
Comparative sample 8	0.2	-	C	C	190
Comparative sample 9	0.2	-	C	C	165
Comparative sample 10	0.2	1.0	C	A	120

As shown in Table 1, electrophotographic photoconductors having
5 no optical sensitivity decline, and excelling in chargeability are
obtained as a result of samples 1 to 10.

[0103]

(Sample 11)

An electrophotographic photoconductor is produced by the

procedure identical to the sample 1 except that a composition of the coating solvent for the charge transport layer is altered to the composition as shown below.

[Coating solvent for the charge transport layer]

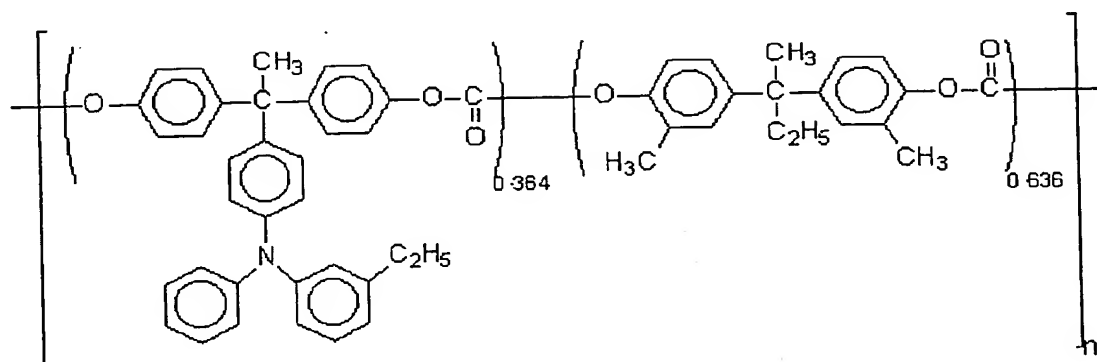
Polymer charge transport material of a following formula 16: 10 parts

Silicon oil (KF-50, available from Shin-Etsu Chemical Co., Ltd.): 0.001 parts

Tetrahydrofuran: 100 parts

[0104]

[Formula 16]



[0105]

(Sample 12)

A surface protection coating layer is applied to the photoconductor of the sample 1, and dried at 149 °C for 20 minutes so that a surface protection layer of an average thickness of 2 μm is formed, and an electrophotographic photoconductor is produced.

[Surface protection coating solvent]

Layer Polycarbonate resin; 3.8 parts

(Iupilon Z200, available from Mitsubishi Engineering-Plastics Corporation.)

Charge transport material of formula 7: 2.8 parts

α-alumina: 2.6 parts

(Sumikorandom AA-04, available from Sumitomo Chemical Co., Ltd.)

Cyclohexane: 80 parts

Tetrahydrofuran: 280 parts

[0106]

Each of the electrophotographic photoconductors produced as the samples 1, 11, and 12 is disposed in a process cartridge for the image forming apparatus similar to a model shown in Fig. 5. The semiconductor laser of 780 nm, and a contact charge roller charger are disposed in the image forming apparatus (imagio MF-2200, available from Ricoh Co., Ltd.) as the image irradiation means and the charge means, respectively. Then test printing of A4 150,000 PPC sheets in the longitudinal direction is conducted. Evaluation of images is determined by background fog, image density, and rated as A. good, B. fair, and C. failure. Results are shown in table 2.

[0107]

15 [Table 2]

	Surface protection layer	Image evaluation		Abrasion (μm)
		Background	Image density	
Sample 1	Without surface protection layer	B	A	9.2
Sample 11	Without surface protection layer	A	A	2.4
Sample 12	With surface protection layer	A	A	0.2

As shown in Table 2, the electrophotographic photoconductors of the samples 11, and 12 particularly excel in abrasion resistance.

[0108]

20 (Sample 13)

The photoconductor produced as sample 1 is disposed in the image forming apparatus (imagio MF-2200, available from Ricoh Co., Ltd.) having the modification to dispose a closely spaced non-contact roller charger, and the gap between the photoconductor surface, and the charger surface is adjusted to 50 μm . As shown in sample 1, test printing of A4 100,000 PPC sheets in a longitudinal direction is conducted.

[0109]

(Sample 14)

The photoconductor produced as sample 1 is disposed in the image forming apparatus (imagio MF-2200, available from Ricoh Co., Ltd.) having the modification to dispose a closely spaced non-contact roller charger, and the gap between the photoconductor surface, and the charger surface is adjusted to 180 μm . As shown in sample 1, test printing of A4 100,000 PPC sheets in a longitudinal direction is conducted.

[0110]

(Sample 15)

The photoconductor produced as sample 1 is disposed in the image forming apparatus (imagio MF-2200, available from Ricoh Co., Ltd.) having the modification to dispose a closely spaced non-contact roller charger, and the gap between the photoconductor surface, and the charger surface is adjusted to 250 μm . As shown in sample 1, test printing of A4 100,000 PPC sheets in a longitudinal direction is conducted.

[0111]

(Sample 16)

The photoconductor produced as sample 1 is disposed in the image forming apparatus (imagio MF-2200, available from Ricoh Co., Ltd.) having the modification to dispose a closely spaced non-contact roller charger, and the gap between the photoconductor surface, and the charger surface is adjusted to 100 μm . As shown in sample 1, test printing of A4 100,000 PPC sheets in a longitudinal direction is conducted.

<Charge condition>

DC bias: -850 V

AC bias: Not used

[0112]

(Result)

Samples 13 to 16 are evaluated, and results identical to sample 1 are obtained. A halftone image is outputted after the test printing of 100,000 according to samples 13 to 16. Although according to

samples 1, 13, and 14, images of good quality is outputted, slight unevenness in density due to uneven charging is observed in samples 15, and 16.

[0113]

5 (Sample 17)

The photoconductor produced as sample 12 is disposed in the image forming apparatus (imagio MF-2200, available from Ricoh Co., Ltd.) of the sample 12 having a modification to replace a contact charger roller with a scorotron charger. As in the procedure identical to
10 sample 11, test printing of 150,000 sheets is conducted. After the test printing of 150,000, images on 50 sheets are outputted at a temperature of 30 °C, and humidity of 90 %.

[0114]

(Result)

15 According to 17, results of the test printing of 150,000 are similar to the result of the sample 12. Nevertheless, a significant ozone smell is observed during the test. Further, images printed at a temperature of 30 °C, and in humidity of 90 % are evaluated. Images are slightly blurred according to sample 17, as opposed to
20 the good quality obtained for the sample 12.

[0115]

[Effects of the Invention]

As explained in detail and concretely, an electrophotographic photoconductor having no optical sensitivity decline in initial
25 use and with repeated use when a halogen-free solvent is used, and excelling in chargeability, and a production method of the electrophotographic photoconductor, an image forming apparatus and a process cartridge for an image forming apparatus using the electrophotographic photoconductor are provided according to the
30 present invention.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a cross-sectional view of an example structure of an

electrophotographic photoconductor according to the present invention.

[Fig. 2]

Fig. 2 is a different cross-sectional view of an example structure of the electrophotographic photoconductor according to the present invention.

[Fig. 3]

Fig. 3 is a schematic illustrating an electrophotographic process, and the image forming apparatus of the present invention.

10 [Fig. 4]

Fig. 4 is an example showing a closely spaced charge mechanism having a gap forming member in a charge member.

[Fig. 5]

Fig. 5 is an example showing a process cartridge of a general form.

[Fig. 6]

Fig. 6 is a graph showing results of X-ray diffraction spectrum tests of titanyl phthalocyanine powder.

[Reference Numerals]

20	1	Photoconductor
	2	Charge elimination lamp
	3	Charge roller
	5	Image irradiation unit
	6	Developing unit
25	7	Pre-transfer charger
	8	Registration roller
	9	Transfer sheet
	10	Transfer charger
	11	Separation charger
30	12	Separation nail
	13	Pre-cleaning charger
	14	Fur brush
	15	Cleaning brush

16 Development roller
17 Transfer roller
21 Gap forming member
22 Metal forming area
5 23 Image forming area
24 Non-image forming area
31 Photoconductive support body
33 Middle layer
35 Charge generation layer
10 37 Charge transport layer

[Selected Drawing]

[Fig. 1]

[Name of Document] Abstract of the Disclosure

[Abstract]

15 [Objectives of the Invention]

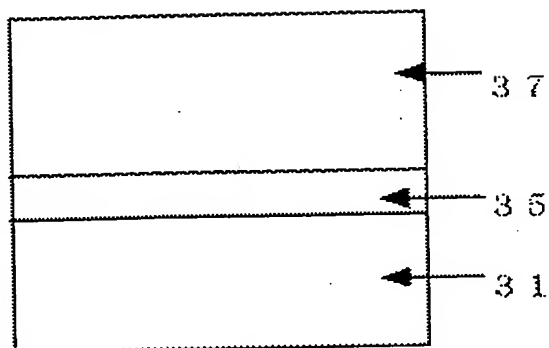
To provide an electrophotographic photoconductor having no optical sensitivity decline in initial use and with repeated use when a halogen-free solvent is used, and excelling in chargeability, and a production method of the electrophotographic photoconductor, an image forming apparatus and a process cartridge for an image forming apparatus using the electrophotographic photoconductor.

[Means for Achieving the Objectives]

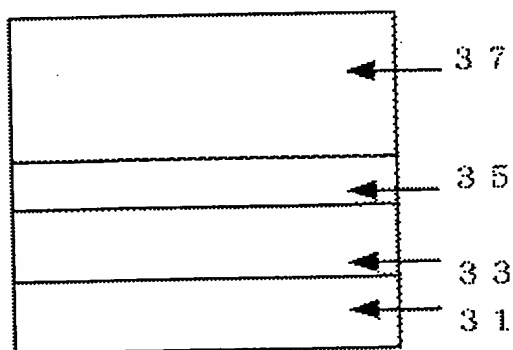
An electrophotographic photoconductor including a charge transport layer having at least a charge generation layer, and a halogen-free solvent in the order on an electroconductive support body, forming a charge generation material having an average particle diameter smaller than surface roughness of the electroconductive body in the charge generation layer, and a polyvinyl acetal resin having a ratio (Mw/Mn) of weight-average molecular weight Mw to an amount of number-average molecular weight of 2.2 or more.

[Name of Document] Drawings

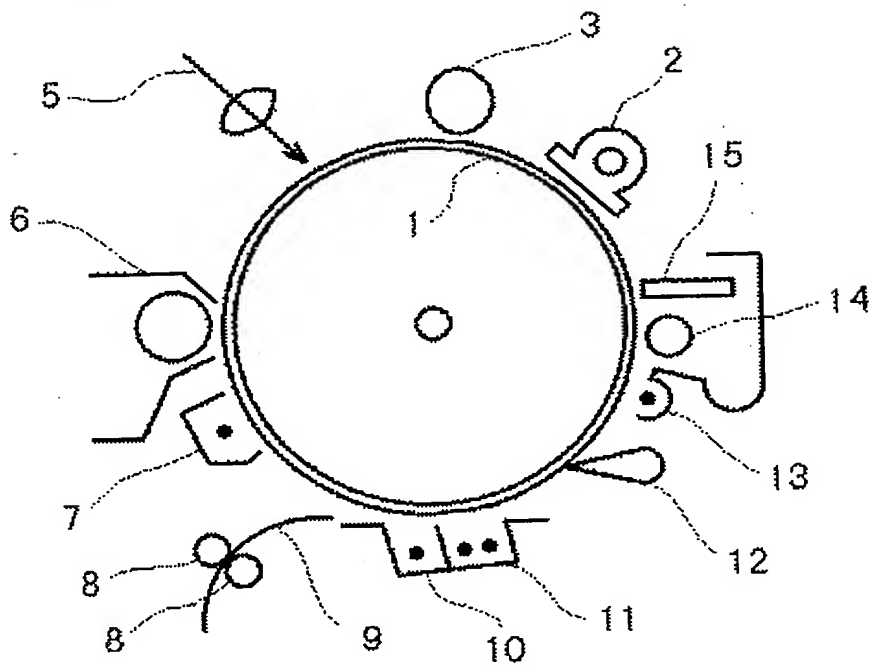
[Fig. 1]



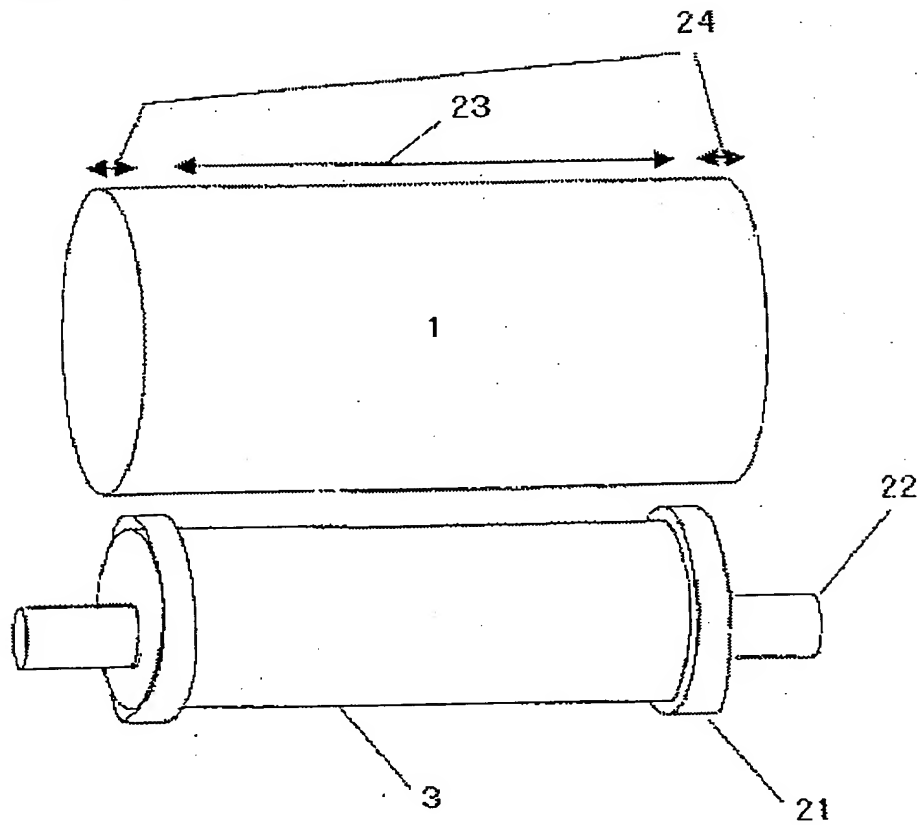
[Fig. 2]



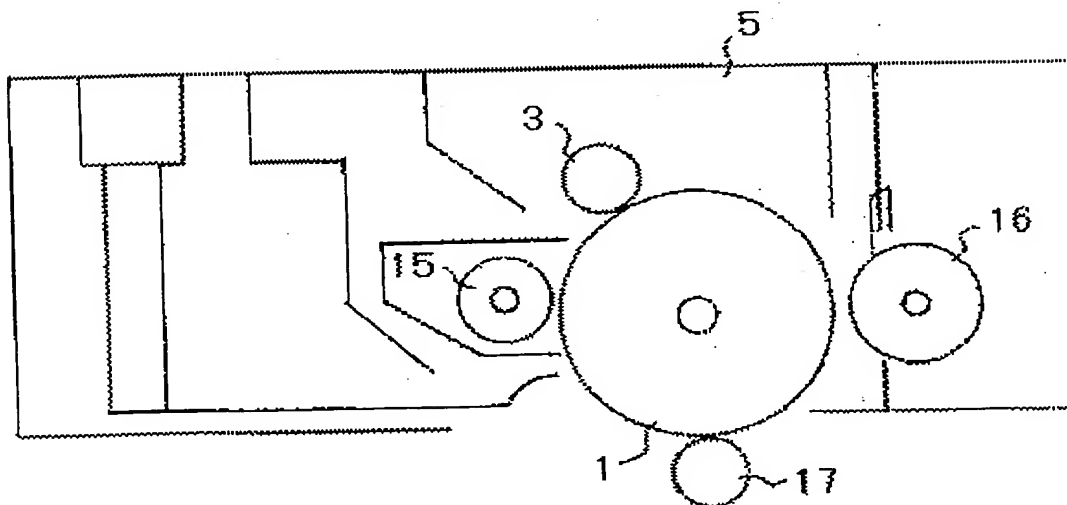
[Fig. 3]

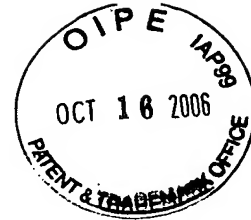


[Fig. 4]



[Fig. 5]





[Fig. 6]

